Survival of Hook-caught Red Drum

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Abstract: Sub-legal red drum (<355 mm) collected with angling gear during 1988 and 1989 were held in confinement to evaluate post-hooking survival. Short-term post-hooking survival was 84% in both years. Most fish were hooked in the maxilla area and 92% of these individuals survived. Gill-hooked fish comprised 13% of the red drum collected and exhibited 68% survival. Only 10% were hooked in the esophagus; however, these fish had the lowest survival (47%). Angler recapture rates of marked hook-caught red drum were similar to those of marked net-captured fish during 1988. The significant difference in return rates during 1989 is likely a result of poor tag performance and not post-hooking mortality.

Proc. Annu. Conf. Southeast. Assoc. Fish. and Wildl. Agencies 46:337–344

Length and bag limits have been used in the management of freshwater recreational fisheries for several decades (Redmond 1986). The success of such management measures depends on release and survival of hook-caught finfish. Studies of post-hooking survival in freshwater have been used to improve the public's perception of catch and release, develop valid harvest regulations, and provide information on proper handling techniques (Graff 1987).

Throughout the southeastern United States, demand for quality marine recreational angling is increasing (Schmeid and Burgess 1987). Unprecedented harvest restrictions are being used to moderate fishing mortality, optimize yield, and maintain reproductive stability of many marine finfish stocks. Diversity of targeted species and exploitable habitats within this region confounds efforts to quantify post-hooking survival. While research has been conducted on selected estuarine sportfish in the Gulf of Mexico (Hegen et al. 1984, Garrett 1988), little is known about survival of the many regulated species in the South Atlantic region.

The red drum (*Sciaenops ocellatus*) is one of the most popular marine sportfish in Georgia and throughout the southeastern United States (Pafford and Nicholson

1989, Schmeid and Burgess 1987). However, this species' qualities as a sport and food fish has led to overfishing (Vaughan 1992). Young-of-year fish (YOY), which congregate in large numbers at the mouths of tidal creeks, are extremely vulnerable to capture with hook and line gear. Peak abundance of these small red drum occurs during the summer months when angling effort is highest. From 1979 through 1985, >70% of the red drum harvested in Georgia were <355 mm (Pafford and Nicholson 1989). As red drum typically do not mature until the fifth year of life or at lengths in excess of 700 mm (Music and Pafford 1984), fishery managers were concerned about the impacts of this intense harvest of immature fish.

During 1986, a 355 mm minimum size limit was implemented by the Georgia General Assembly to reduce growth overfishing and improve the quality of the fishery. Fishery-independent and -dependent surveys following imposition of the minimum size limit (Pafford et al. 1990) indicated additional harvest restrictions were needed. In 1989, a 10 fish per person daily creel limit was established by the Georgia Department of Natural Resources (DNR) to further moderate fishing mortality and enhance survival to adulthood. In 1991, this limit was reduced to 5 red drum per angler.

Following implementation of initial size restrictions and subsequent creel limits, anglers complained that undersized fish often die when caught on hook and line gear. Consequently, many believed mandatory release of red drum was an inappropriate action and voluntary compliance was jeopardized. Fishery managers also questioned the effects of post-release mortality on the catch statistics used in stock assessments of South Atlantic red drum.

Study objectives were to determine short-term and long-term survival of hook-caught sub-legal red drum. The effects of hook position on survival would also be examined. Study findings could be used to evaluate the efficacy of current harvest regulations, recommend gear and handling techniques for anglers, and improve voluntary compliance.

The authors would like to acknowledge the contribution of all the personnel of the Recreational Fisheries Program during the course of this study. John M. Pafford deserves special recognition for his initial idea for an investigation of post-hooking survival in red drum. Funding for this study was provided through Federal Aid in Sport Fish Restoration (Proj. F-31).

Methods

YOY red drum recruit to recreational fishing gear as early as May of the year following spawn; however, peak abundance of sub-legal individuals usually occurs during summer months. Therefore, sampling efforts were concentrated during June through September of 1988 and 1989.

Gear and techniques favored by Georgia anglers were utilized to collect experimental fish. Single shank hooks of various materials in sizes 4 to 3/0 were used on both float and bottom rigs deployed from small boats. Live and dead penaeid shrimp were used most often as bait.

Red drum used as controls were collected with monofilament gill and trammel nets in the same areas as experimental fish. These fish were subject to identical tagging and transportation procedures as hook-caught fish. All field activities occurred within 25km of the holding facility located on the St. Simons estuary. Surface water temperatures (° C) and salinities (ppt) were recorded at each collection site.

Experimental hook-caught fish were examined, measured, and tagged. Hook type, size, and location were recorded, and the fish was temporarily placed in a nylon mesh holding net until sampling was completed. Fish were transported between sample sites in an aerated 114-l cooler. Fish were returned to the holding net upon arrival at the next sampling area. This procedure was repeated until cessation of angling when all fish were transported to the holding facility.

Location of the hook was defined as follows: maxilla, gill, and esophagus. The hook was removed from all individuals hooked in the maxilla. Individuals hooked in the gill and esophagus region were randomly selected to have either the hook removed or the leader cut leaving the hook in the fish.

Short-term survival of red drum was evaluated by holding hook-caught and control fish at DNR Coastal Regional Headquarters in Brunswick, Georgia. Fish were placed in 3785-l circular fiberglass tanks supplied with a continuous flow of ambient estuarine water drawn from a nearby tidal creek. Visual observations were made daily to detect mortality. Fish were fed a diet of live shrimp and fiddler crabs while in confinement.

Both control and hook-caught fish used in the short-term phase of the study were held a minimum of 14 days before release. An exception was made for individuals in which the hook remained. These fish were held until the hook deteriorated, dislodged, or the fish died.

A maximum of 60 fish was held per tank during confinement, of which a minimum of 30% were controls. Water levels in the holding tanks were lowered every third day during a confinement period for tank cleaning and fish examination. All dead fish were removed immediately.

Long-term survival of hook-caught fish was evaluated in a mark-recapture study. During angling activities, randomly selected individuals were tagged and measured, data on hook type and location were recorded, and fish were immediately released back into the area of capture. Experimental fish which survived the confinement period were examined, their physical condition was recorded, and they were released into a tidal creek near the holding facility. Angler returns of external tags were used to describe long-term survival of hook-caught fish.

Numbered internal Floy anchor tags (FD-68BC) were used to identify individual experimental and control fish during 1988. Anchor tag disks were inserted through a vertical incision in the external wall of the abdominal cavity. The tag streamer protruded from the body cavity near the tip of the pectoral fin (Moffett 1961, Music and Pafford 1984). In 1989, numbered plastic dart tags (PDT) were used to mark fish. Dart tags were inserted at the base of the spiny dorsal fin using a modified stainless steel canula following the method of Qualia (1987).

Survival rates of experimental fish were adjusted for the possible effects of

transportation and confinement using control mortality estimates. Statistical comparisons of survival rates of hook-caught fish and tag return rates were made with a Chi-square test (Sokal and Rohlf 1981) to determine differences in probabilities.

Results and Discussion

During 1988, 217 sub-legal red drum were collected with hook and line gear. An additional 65 control fish were collected with trammel and gill nets. In 1989, a total of 296 hook-caught and 103 net-caught red drum were used in the study. The fork lengths of experimental and control fish ranged from 199 to 355 mm. Information on monthly sample numbers, post-confinement survival, and physicochemical data is in Table 1. Survival rates for control fish were 97% in 1988 and 93% in 1989. All of the following rates of survival have been adjusted for control mortality.

Overall survival during 1988 and 1989 was 84%. Data from both years were combined to evaluate survival based on hooking location (Table 2). Throughout the study, most red drum (77%) were hooked in the maxilla. Of those, 359 (92%) survived the confinement period. Only 13% of the sub-legal red drum were hooked in the gill area. These fish exhibited a survival rate of 68%. Small red drum hooked in the esophagus accounted for 10% of the experimental fish and 47% of these survived confinement. Survival rates were significantly different among the 3 hooking positions ($P < 0.001$).

Survival of sub-legal red drum was influenced by removal of the hook from the fish. Small red drum hooked in the gill region exhibited lower survival (54%) when the hook was not removed. A total of 79% of the individuals with the hook removed from the gills survived. Survival was 50% for sub-legal red drum hooked in the esophagus with hooks left intact. This value was somewhat less (41%) for individuals hooked in the esophagus when the hook was removed. These results indicate that removal of the hook, when appropriate, can contribute to improved post-hooking survival in small red drum.

Mortality of red drum hooked in the maxilla or gills (hooks removed) occurred within 1–10 days of capture. The longest period between capture and mortality for an individual fish in which the hook remained was 29 days. Red drum hooked in the esophagus were the only experimental fish to die immediately following capture (<20 minutes). Time necessary for hooks to either deteriorate or dislodge ranged from 2–28 days.

Mason and Hunt (1967) and Warner (1979) found that survival of hook-caught salmonids was enhanced by leaving the hook in the gut region. In small red drum, a hook lodged in the gill area can be easily reached with a hook removal device, whereas a hook in the esophagus usually cannot be seen much less removed. Many times the angler must pull the hook from the esophagus using the attached leader. This process apparently produces more bleeding and tissue damage than the initial hooking and causes greater physical harm. During this study, several small red drum with hooks left in the gill and esophagus continued to feed actively while in confinement.

Table 1. Monthly catch, post-confinement survival, and physicochemical data for red drum survival, 1988 and 1989.

Date	*N*	Survival (%)	Mean salinity (ppt)	Mean temp (°C)
1988				
Jun	7	86	30	28
Jul	58	81	34	29
Aug	87	90	32	29
Sep	57	74	30	29
Oct	8	100	30	30
Total	217	84		
1989				
Jun	34	79	30	30
Jul	112	80	32	29
Aug	89	87	31	29
Sep	61	85	30	29
Total	296	84		
Grand Total	513	84		

Table 2. Post-confinement survival of sub-legal red drum based on hook location.

Hook location	*N*	Survival (%)
Maxilla	394	92
Gill	67	68
hook removed	36	79
hook not removed	31	54
Esophagus	52	47
hook removed	16	41
hook not removed	36	50
All hook positions	513	84

Warner (1978), working with Atlantic salmon, suspected that larger fish would suffer greater physical damage from a hook during the landing process; however, he reported no difference in mortality related to size. Dotson (1982) and Titus and Vanicek (1988) also could show no significant correlation between fish size and survival in released cutthroat trout. Garrett (1988) reported overall survival of hook-caught red drum from a Texas reservoir as 55% and found that mortality increased with fish length.

In the present study, survival varied slightly when based on length at capture (Table 3). This suggests that size has little influence on post-hooking survival in sub-legal red drum. The 250 mm size class appeared to suffer greater mortality; how-

Table 3. Hooking location and post-confinement survival of sub-legal red drum based on size at capture.

Size class (mm TL)	Hook location		Survival (%)
	Maxilla (*N*)	Gill/esophagus (*N*)	
200	20	2	77
225	43	10	83
250	34	54	65
275	124	21	90
300	85	15	84
325	68	14	85
350	21	3	85

ever, a disproportionate number of fish in this length group were hooked in the gill and esophagus thus contributing to the observed lower survival.

In 1988, 217 red drum were held for observation of which 181 were released following confinement. In addition, 57 red drum were tagged and released in the field, for a total of 238 hook-caught individuals available for recapture. The angler return rate of hook-caught red drum released in 1988 was 19%, which was similar ($P > 0.05$) to the return rate (26%) of net-caught tagged juvenile red drum in St. Simons estuary during the same year. Of 46 marked red drum recovered, 38 were individuals which survived confinement and the remaining 8 were hook-caught fish which had been released in the field. The earliest angler return came within 14 days of release, while the longest time at liberty for a hook-caught red drum tagged with an internal anchor tag was 931 days.

In 1989, 296 hook-caught red drum were held for observation, of which 245 were released following confinement. No hook-caught red drum were released in the field in 1989. Only 6% of the tags from hook-caught red drum released in 1989 were returned. This is significantly less ($P \leq 0.001$) than the return rate of 21% for red drum tagged and released during mark-recapture activities in 1989. Hook-caught fish tagged with dart tags were recovered by anglers as early as 31 days post-release, while the longest time at large was 125 days.

A tag retention and tagging mortality study of juvenile red drum utilizing internal anchor tags indicated that short-term tag loss and mortality of tagged fish was zero (K. Shaffer, unpubl. data). During the 1989 phase of the red drum hooking-survival study, approximately 27% of the marked fish, both controls and experimentals, lost their dart tags during the confinement period.

Long-term performance of dart tags in juvenile red drum is undocumented; however, recent double tagging experiments in Georgia indicate that retention of dart tags is poor in red drum <400 mm (A. G. Woodward, unpubl. data). Consequently, the difference in return rates of marked hook-caught fish between years is likely a result of dart tag loss and not long-term mortality.

Summary

Results of this study indicate that survival of hook-caught red drum, although influenced by hook location, is much greater then believed by many anglers. During the course of this study, small red drum were subject to multiple handlings, confinement, and tagging. All of these factors can compound the deleterious effects of hooking. While catch and release skills vary among anglers, we believe that hook-caught fish in the present study were subject to more rigorous treatment than would normally be experienced during angler capture and release. Consequently, survival of hook-caught sub-legal red drum should be greater than the observed value of 84% when proper release techniques are used.

Findings from the present study have allowed scientists concerned with the status of Atlantic coast red drum to improve the accuracy of the catch statistics used in current stock assessments. Prior to this study, investigators assumed all red drum caught and released within the recreational fishery would survive. With more harvest restrictions, the number of fish reported as released alive has increased in recent years. Using the results of this study, Vaughan (1992) adjusted the catch by weight estimates from the 1991 Marine Recreational Fisheries Statistics Survey to account for 10% release mortality of red drum.

In Georgia, sub-legal red drum abundance and coastal fishing effort peak concurrently during midsummer (Pafford and Nicholson 1989, Nicholson et al. 1990). Much of this fishing effort is by non-coastal residents, many of whom are unfamiliar with saltwater fishing techniques and gear. These anglers often use tackle and small hooks suitable for freshwater species such as Centrachid sunfish. Small hooks probably increase the incidence of hooking in the gill and esophagus. Sub-legal red drum hooked in these locations exhibited the poorest survival during this study.

Results of this study indicate that small red drum hooked in the gills will have greater survival if the hook is removed. Conversely, fish hooked in the esophagus fare better if the hook is left intact and the leader cut. With this knowledge, anglers can improve the survival of small red drum by removing hooks when appropriate. Educational efforts should also encourage saltwater anglers to use larger hooks when suitable for their fishing method to minimize the chance of hooking small fish in the gill or esophagus. Dissemination of information on post-hooking survival to the public is of critical importance as it will allow anglers to have greater confidence in releasing hook-caught fish. Improved voluntary compliance is necessary if harvest regulations are to be effective for moderating fishing mortality in Georgia's marine recreational fishery.

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